AN ASSESSMENT OF THE MACROINVERTEBRATES OF JAMES CANYON CREEK & BURNOUT CREEK IN JUNE 2004

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INTRODUCTION

James Canyon Creek and Burnout Creek of the Huntington Creek Drainage Basin, Emery County, Utah, are located in an area subject to subsidence due to coal mining activities. Both streams have been monitored since the fall, of 2000 to document any changes associated with subsidence in their watersheds.

This report on James Canyon Creek and Burnout Creek will cover samples taken up to June 22, 2004. The June 2004 samples represent the eighth set of benthic invertebrate samples taken at James Canyon Creek and the seventh set that has been taken at Burnout Creek.

METHODS

Quantitative samples were taken with a modified box sampler (Shiozawa 1986). The capture net was constructed with nitex nylon mesh with openings of 253 microns. Three samples were taken at both James Canyon Creek and Burnout Creek, as prescribed to Canyon Fuels Corporation by the Utah Division of Wildlife Resources. The samples were preserved in the field with ethyl alcohol and were returned to the laboratory for processing. The samples were sorted in a backlit illuminated pan. Organisms were identified to the lowest taxonomic unit possible. Small specimens and those of questionable identity were examined under magnification. After the sample had been sorted with the unaided eye and visible invertebrates removed, the remaining material was subsampled and examined under magnification to insure that accurate counts of the early instars were included. Identification was based on the keys of Merritt and Cummins (1994). The mean counts for each taxon were used to determine the density per square meter. Standing crop was estimated from wet weights of total invertebrates collected at each station.

The USFS Biotic Condition Index (Winget and Mangum 1979) was calculated with the community tolerance quotient (CTQa) and the predicted community tolerance quotient (CTQp). CTQp estimates were based on water chemistry data provided in Winget (1972) for the Huntington Creek drainage, and both streams had CTQp values of 80. Diversity was calculated using the Shannon-Weiner index (Pielou 1977). Cluster analysis was run with NTSYS-pc, using the Bray-Curtis dissimilarity index with the UPGMA clustering algorithm. Data from all sampling periods (fall, 2000 through spring, 2004) for both Burnout Creek and James Canyon Creek have been included in the cluster analysis.

Table 1. Sampling station locations

Canyon	GPS coordinates	Elevation
James	N 39°38.033' W 111° 13.739'	8627 ft
Burnout	N 39° 38.929' W 111° 14.171'	8613 ft

RESULTS AND DISCUSSION

Biological Characterization

Number of Taxa

Twenty-two taxa were collected in Burnout Creek in the spring, 2004 sampling series (Table 1). This was a 4% decrease from the spring, 2003 samples. This is the lowest number of taxa thus far recorded in a spring sample from Burnout Creek. This sample series had 7 fewer taxa than the long term site average of 29. The ephemeropteran *Serratella* and nematodes were recorded in Burnout Creek for the first time.

Twenty-nine taxa were recorded from James Canyon Creek in the spring, 2004 sampling series (Table 1). This was six taxa more than the previous spring sample, a 26% increase, but still below the long term site average of 28. Two new taxa were found in James Canyon Creek, the coleopteran family *Curculionidae* and representatives of the Nematoda.

Table 2. Number of Taxa collected from Burnout and James Canyon Creeks

	Fall 2000	Spring 2001	Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
Burnout Creek	33	34	27	30	-	23	26	22
James Canyon Creek	31	35	30	27	24	23	27	29

Total Densities

Burnout Creek had a total density of 22,513 organisms per square meter. This was an 11% decrease in taxa per square meter from the spring, 2003 sample. The long-term site average is 31,193 organisms per square meter. James Canyon Creek recorded a total density of 83,719 organisms per square meter. This was a 63% increase in taxa per square meter over the spring, 2003 sample. The spring, 2004 sample for Burnout exceeded the site average of 44,115 by nearly 40,000 organisms per square meter.

The spring, 2004 total density in Burnout Creek appears to be well within the expected range, based on the spring estimates for previous years. Of the fall samples, only the fall, 2003 densities were above what might be expected. This may be a factor of the change in sorting procedures instituted in 2002. Following that change higher counts are expected because the samples are more accurately sorted. However the numbers recorded in Burnout Creek in the spring of 2003 do not show that same increase. This difference may be influenced by the reproductive cycles of the dominant organisms in Burnout Creek. Many aquatic insects reproduce in the summer and high numbers of small, early instar offspring are found in fall samples. By spring many of these have grown, and are easily seen during sorting.

James Canyon Creek, after the fall of 2001, shows a steady increase in total density until the spring of 2004. This indicates that processes in James Canyon Creek are acting independently of the dynamics in Burnout Creek. Part of the increase will be associated with the change in sample processing, but the spring densities in James Canyon Creek densities continued their increase in the spring of 2003 and 2004. This may be related to the loss of access to the stream by spawning trout which was associated with the fall in the water level in Electric Lake.

Table 3. Total invertebrate densities per square meter for Burnout and James Canyon Creeks

	Fall 2000	Spring 2001	Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
Burnout Creek	12590	35236	19995	38167	-	25178	55995	22513
James Canyon Creek	34732	31344	11716	30309	40161	51488	109060	83719

Taxa Specific Densities

In Burnout Creek, the dominant species were (Table 4): Ostracoda (Crustacea; 5,787/m^2), : *Baetis* (Ephemeroptera; 3,899/m^2), and Chironomidae (Diptera; 3,343/m^2). These made up, 26%, 17%, and 15% of the total density, respectively. Within Burnout Creek the following taxa occurred in densities greater than 500 per square meter: *Baetis*, *Cinygmula* (Ephemeroptera), early instar Ephemeroptera, early instar Plecoptera, *Heterlimnius* (Coleoptera), *Optioservus* (Coleoptera), Chironomidae, Ostracoda, and Oligochaeta (Annelida).

In James Canyon Creek, the dominant species were (Table 5) Chironomidae (59,751/m^2), Ostracoda (7,040/m^2) and *Baetis* (3,010/m^2). These made up 71%, 8%, and 4% of the total density respectively. Within James Canyon Creek the following taxa occurred in densities greater than 500 per square meter: *Baetis*, *Cinygmula*, *Heptagenia* (Ephemeroptera), early instar Plecoptera, *Neothremma alicia* (Trichoptera), *Oligophlebodes* (Trichoptera), *Rhyacophila* (Trichoptera), Ceratopogonidae (Diptera), *Chelifera* (Diptera), Chironomidae, Copepoda (Crustacea), Ostracoda, Hydracarina (Arachnida), Oligochaeta and Planariidae (Tricladida).

In the fall, 2003 sampling period at Burnout Creek the species driving the high densities were *Baetis*, *Cinygmula*, *Drunella*, early instar ephemeropetrans, *Brachycentrus*, *Simuliium*, Ostracoda Ceratopogonidae, and *Hydracarina*. In the spring of 2004 *Baetis* and early instar ephemeropterans and plecopterans were still in high numbers. The mayfly *Seretlla* was also abundant. The total densities had returned to levels similar to previous sampling periods.

Table 4. Summary of invertebrate densities by taxa for Burnout Creek Spring 2004

	Fall 2000	Spring 2001	Fall 2001	Spring 2002	Spring 2003	Fall 2003	Spring 2004
Ephemeroptera: *Baetis*	404	949	848	545	879	11403	3899
Ephemeroptera: *Cinygmula*	566	10	1050	636	525	4909	1263
Ephemeroptera: *Drunella doddsi*			10			778	
Ephemeroptera: *Drunella grandis*		20	20	10	40	61	
Ephemeroptera: *Epeorus iron*				71	10		121
Ephemeroptera: *Ephemerella*	182	20		71		91	
Ephemeroptera: early instar*			101			6222	929
Ephemeroptera: *Heptagenia*	91			10			
Ephemeroptera: *Paraleptophlebia*	1161	40	525	10			
Ephemeroptera: *Rhithrogena*	10			10			
Ephemeroptera: *Serratella*							222
Plecoptera: early instar*	50	20		10		20	626
Plecoptera: *Diura knowltoni*	20						
Plecoptera: *Hesperoperla pacifica*						10	
Plecoptera: *Isoperla*	71	10	10	10	20		
Plecoptera: *Malenka californica*	141						
Plecoptera: *Megarcys signata*			10				
Plecoptera: *Skwalla parallela*		10		10		30	
Plecoptera: *Sweltza*	50		20			10	
Plecoptera: *Zapada*	10	10				40	
Trichoptera: pupae					10		20
Trichoptera: *Amiocentrus*		10					
Trichoptera: *Brachycentrus echo*		10	30	10	10	1020	
Trichoptera: *Dicosmoecus*		10	131				10
Trichoptera: *Ecclisocosmoecus*	20						
Trichoptera: *Hydropsyche*					10	20	
Trichoptera: *Lepidostoma*	10	71		30			30
Trichoptera: *Limnephilus*					10		
Trichoptera: *Micrasema*	10	131	141	242			
Trichoptera: *Moselyana*	20						
Trichoptera: *Neothremma alicia*	252	81	101	51	152	333	40
Trichoptera: *Oligophlebodes*	40	202	515	30			
Trichoptera: *Platycentropus*		10					

Trichoptera: *Rhyacophila* (larvae)	121	101	121	202	576	707	111
Trichoptera: *Rhyacophila* (pupae)							
Coleoptera: *Heterlimnius* (larvae)	353	2828	2505	455	10	20	525
Coleoptera: *Heterlimnius* (adult)	40	51	152	71			121
Coleoptera: Hydrophilidae		10					
Coleoptera: *Optioservus* (larvae)	71			1262	1111	5838	859
Coleoptera: *Optioservus* (adult)				161	40	677	30
Diptera: pupae*						30	
Diptera: *Agabus*					10		
Diptera: *Antocha* (larvae)	40	152		50			
Diptera: *Antocha* (pupae)		20					
Diptera: *Caloparyphus*		20	40				20
Diptera: Ceratopogonidae		20	20		30	2535	
Diptera: *Chelifera*		121			10		
Diptera: Chironomidae (larvae)	3919	21927	2636	29685	13080	4192	3343
Diptera: Chironomidae (pupae)		485		1010	51	505	20
Diptera: *Dicranota*	20	10	10	10		20	
Diptera: *Euparyphus*	20		10			61	
Diptera: *Pericoma*	111		10				
Diptera: *Ptychoptera*	81						
Diptera: *Simulium* (larvae)	121	30	323	81	212	2192	323
Diptera: *Simulium* (pupae)		30		10			
Diptera: *Tipula*	10	30	40	10	40	182	30
Crustacea: *Asellus*	10						
Crustacea: Cladocera		495		545			313
Crustacea: Copepoda				10	303	1525	303
Crustacea: Ostracoda	4202	5181	5656	1576	6454	10878	5787
Arachnida: Hydracarina	20	202		10	313	626	323
Mollusca: *Sphaerium*	40	364	253	364	929	1030	40
Annelida: Oligochaeta	303	899	3596	636	343	30	2747
Tricladida: Planariidae		626	1111	263			424
Collembola		20					20
Nematoda							10
Number of taxa*	33	34	27	30	23	26	22
Totals	12590	35236	19995	38167	25178	55995	22513

Table 5. Summary of invertebrate densities by taxa for James Canyon Creek Spring 2004

	Fall 2000	Spring 2001	Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
Ephemeroptera: *Baetis*	2848	1030	2444	404	6757	2283	18241	3010
Ephemeroptera: *Cinygmula*	313	384	404	485		697	5040	535
Ephemeroptera: *Drunella doddsi*			30				40	
Ephemeroptera: *Drunella grandis*		1566		1485		949	20	
Ephemeroptera: *Epeorus iron*				10	283			
Ephemeroptera: *Ephemerella*	980	20	10	91	2434		10	
Ephemeroptera: early instar	30		495			1010	2949	202
Ephemeroptera: *Heptagenia*	30							1101
Ephemeroptera: *Paraleptophlebia*	40		81	20	91			
Ephemeroptera: *Rhithrogena*		51						
Plecoptera: early instar	646	879	30	293	152	20	1626	768
Plecoptera: *Alloperla*						10		
Plecoptera: *Diura knowltoni*								
Plecoptera: *Hesperoperla pacifica*							61	
Plecoptera: *Isoperla*	71		51	10	212		10	20
Plecoptera: *Malenka californica*	10		142		121			
Plecoptera: *Megarcys signata*			10					
Plecoptera: *Parleuctra*								111
Plecoptera: *Paraperla*		10						10
Plecoptera: *Skwalla parallela*		414		61			111	
Plecoptera: *Sweltza*		10	30					
Plecoptera: *Zapada*	242	111	182	111	758		2010	
Trichoptera: *Allomyia*	131							
Trichoptera: *Amiocentrus*								
Trichoptera: *Arctopsyche grandis*	51		10		20			
Trichoptera: *Brachycentrus echo*		172		10				
Trichoptera: *Dicosmoecus*	10			30	10		182	10
Trichoptera: *Ecclisocosmoecus*								
Trichoptera: *Hydropsyche*		10			10		20	
Trichoptera: *Lepidostoma*		30	10		172			51
Trichoptera: *Micrasema*	81		30					
Trichoptera: *Moselyana*								
Trichoptera: *Neothremma alicia*	3000	1384	758	727	2475	1848	869	1121

Trichoptera: *Oligophlebodes*		364	153	20				1273
Trichoptera: *Platycentropus*								
Trichoptera: *(Pupa)*								40
Trichoptera: *Rhyacophila* (larvae)	394	798	293	576	556	1040	515	980
Trichoptera: *Rhyacophila* (pupae)		30		30				
Coleoptera: *Curculionidae*								10
Coleoptera: *Heterlimnius* (larvae)	30	192	51					
Coleoptera: *Heterlimnius* (adult)		20		40				
Coleoptera: *Optioservus* (larvae)	10			1263	283	384	81	30
Coleoptera: *Optioservus* (adult)				162	51		20	10
Coleoptera: Staphylinidae		10	10			505		
Diptera: *Antocha* (larvae)	10			10	51			
Diptera: *Antocha* (pupae)								
Diptera: *Atherix*	10							
Diptera: *Atrichopogon*						10		
Diptera: *Caloparyphus*		51	20					30
Diptera: Ceratopogonidae	40	61		10		586	747	606
Diptera: *Chelifera*	51	81		40		91	1030	
Diptera: Chironomidae (larvae)	23533	20614	4464	21947	19917	23351	62963	59751
Diptera: Chironomidae (pupae)	20	455	10	323	20	212	2424	141
Diptera: Chrysogaster						20		
Diptera: *Dicranota*	20						51	
Diptera: *Dixa*		10				81		101
Diptera: *Euparyphus*	10		50		71		141	
Diptera: *Hemerodromia*		10		10				10
Diptera: *Hemerodromia* pupae								20
Diptera: *Limnophila*		20						
Diptera: *Pericoma*	30					1091		
Diptera: Phoridae			10					
Diptera: *Ptychoptera*			10					10
Diptera: *Simulium* (larvae)	91	10	111		939	40	81	20
Diptera: *Simulium* (pupae)								
Diptera: *Tipula*		10			61	81	455	30
Diptera: *Trichoclinocera*		10						
Diptera: *Wiedemannia*	81	91	20					

Crustacea: *Asellus*								
Crustacea: Cladocera		51		343		848		
Crustacea: Copepoda	10					596	980	909
Crustacea: Ostracoda	1778	859	323	162	1202	10837	6363	7040
Arachnida: Hydracarina	10	101	20	81	20	1343	960	929
Mollusca: *Sphaerium*	20	354	71	141		3535	1040	364
Mollusca: *Gyraulus*				0			10	10
Annelida: Hirudinea				0	10			
Annelida: Oligochaeta	101	192	40	394	71	20	10	2444
Tricladida: Planariidae		828	1343	1020	3414			1990
Collembola		51						20
Nematoda								10
Number of taxa*	31	35	30	27	24	23	27	29
Totals	34732	31344	11716	30309	40161	51488	109060	83719

Fewer taxa were associated with the high total abundance in James Canyon in the spring of 2004. In the fall, 2003 sample series *Baetis*, *Cinygmula*, early instars of both ephemeropterans and plecopterans, *Zapada*, chironomids, ostracods, *Chelifera*, ceratopogonids, *Tipula*, *Sphaerium*, copepods, and *Hydracarina* were the taxa that generated the high total density. By the spring of 2004, the total density at James Canyon Creek fell by about 20%, although it was still much higher than in the springs of previous years. The taxa that were important for the high spring density were Heptageneiidae, oligochaetes, chironomids, ceratopogonids ostracods, copepods, and Hydracarina.

Biomass

In the spring of 2004 Burnout Creek recorded its highest spring biomass, 45.87 grams per square meter. This was a 35% increase from the spring, 2003 sample (Table 6). This biomass estimate still falls below the site average of 51.57 grams per square meter. James Canyon Creek biomass (Table 7) for spring, 2004 was 34.07 grams per square meter, a decrease of 53 % from the spring, 2003 biomass estimate. This was also below the site average of 63.34 grams per square meter.

Burnout Creek had its highest biomass in the fall sampling periods. The spring, 2004 samples were slightly higher in biomass than other spring samples, but still showed the expected decline relative to the fall samples. James Canyon Creek had its first significant decline in biomass following a trend of increasing biomass that peaked in the Fall of 2003. The fall, 2004 biomass was the highest that had been recorded in James Canyon Creek over the previous three years of sampling.

Table 6. Biomass in grams for Burnout Creek, 2000-2004

Burnout Creek							
Sample	**F2000**	**S2001**	**F2001**	**S2002**	**S2003**	**F2003**	**S2004**
1	**n/a**	2.02g	1.09g	1.04g	1.26g	3.30g	0.69g
2	**n/a**	0.67g	4.47g	0.94g	1.29g	2.90g	3.31g
3	**n/a**	0.48g	0.78g	1.93g	0.82g	2.54g	0.54g
Total		3.17g	6.34g	3.91g	3.37g	8.74g	4.54g
per m^2	**g/m^2**	32.02 g/m^2	64.03 g/m^2	39.49 g/m^2	34.04 g/m^2	88.27 g/m^2	45.87 g/m^2

Table 7. Biomass in grams for James Canyon Creek, 2000-2004

	James Canyon Creek							
Sample	**F2000**	**S2001**	**F2001**	**S2002**	**F2002**	**S2003**	**F2003**	**S2004**
1	**n/a**	1.16g	0.86g	1.27g	1.03g	1.70g	4.90g	0.47g
2	**n/a**	0.72g	0.63g	2.89g	2.87g	**3.21g**	4.99g	**1.53g**
3	**n/a**	0.62g	0.84g	1.50g	0.55g	2.28g	5.41g	1.33g
Total		2.50g	2.33g	5.66g	4.45g	7.19g	15.30g	**3.33g**
per m^2	**g/m^2**	25.25 g/m^2	25.53 g/m^2	57.17 g/m^2	44.95 g/m^2	72.62 g/m^2	154.53 g/m^2	34.07 g/m^2

<u>Community Tolerance Quotient and Biotic Condition Indices</u>

The community tolerant quotient (CTQa) was generated using the values for individual invertebrate taxa (see Appendix C) assigned in Winget and Mangum (1979). Under this measure lower values represent higher habitat qualities. Generally CTQa values less than 65 represent high quality waters, while those between 65 and 80 represent situations with moderate to high quality water (Winget and Mangum 1979). CTQa values greater than 80 represent low water quality or stressed systems.

The CTQa value for Burnout Creek was 76.3, four points lower than the spring, 2003 sample (Table 8). The previous average CTQa for Burnout was 64.6, which puts the current value twelve points above the average. The spring, 2004 value classifies Burnout Creek as having moderate water quality. The CTQa for James Canyon Creek in the spring of 2004 was 74.8 which was 1 point lower than the spring, 2003 sample. The previous average CTQa for James Canyon Creek was 67.5. This value classifies James Canyon Creek as having moderate water quality.

The BCI allows a comparison of a stream to a physical parameter-based estimate of water quality, the CTQp. Since the Huntington drainage has a CTQp rated at an 80, the BCI = 100 X CTQp/CTQa = 100 X 80/CTQa. Since both streams were rated with the same CTQp value, the BCI will give results parallel with the CTQa. The BCI value for Burnout was 104.8 this was below the site average of 125.2 (Table 8), and the BCI value for James Canyon was 107.0, also below the site average of 119.2.

According to the CTQa and BCI indices, Burnout Creek underwent a significant change in condition in late 2002 or early 2003. James Canyon Creek, which had always had a higher CTQa than Burnout Creek, had an improvement in the stream quality, to a CTQa of 59, in the fall of 2002, but then returned to its previous CTQa range, the mid 60s to mid 70s. The fall of 2002 is when a new processing approach was instituted, and that could be part of the reason for the change in the CTQa/BCI values. However an examination of the taxa lists (Tables 4, 5) indicates that the major change in the data set due to sample processing is associated with changes in densities, and the CTQa/BCI indices are independent of taxon density. Only a few small taxa (e.g. Copepoda) were added, and most had high tolerance quotients and thus would impact the CTQa by increasing it, yet the James Canyon Creek CTQa declined. Burnout Creek may have been influenced by the addition of these taxa in the spring of 2003. By the fall of 2003 both sites had returned to near the same ratings as in the spring of 2002. Both sites again showed an increase in their CTQa for the spring of 2004.

The CTQa has a seasonal periodicity. It is generally higher in the spring (ie. lower water quality), and lower in the fall. In the spring, 2004 samples Burnout Creek is missing a number of both ephemeropteran and plecopteran taxa and James Canyon Creek has reduced taxa in the Plecoptera and Trichoptera. It appears that Burnout Creek has undergone a slight decrease in quality, based on BCI and CTQa, but James Canyon Creek is fluctuating with a season induced periodicity.

Table 8. CTQa and BCI values for Burnout and James Canyon Creeks

	Fall 2000	**Spring 2001**	**Fall 2001**	**Spring 2002**	**Fall 2002**	**Spring 2003**	**Fall 2003**	**Spring 2004**
	CTQa /BCI	CTQa /BCI	CTQa /BCI	CTQa /BCI	CTQa /BCI	CTQa /BCI	CTQa /BCI	CTQa /BCI
Burnout Creek	58.3 /137.2	60.8 /131.6	60.0 /133.3	64.1 /124.8	----	80.1 /99.9	64.4 / 124.3	76.3 /104.8
James Canyon Creek	65.6 /121.9	72.0 /111.1	68.7 /116.4	66.1 /121.0	59.0 /135.9	76.0 /105.3	65.2 / 122.7	74.8 /107.0

Diversity Indices

Diversity indices combine both number of taxa and relative densities into a single measurement. High diversity index values indicate more taxa and a more even number of individuals per taxon. Low diversity values generally reflect a depauperate fauna in both species and somewhat in numbers, although very high densities in just a few taxa will lower diversity scores.

Burnout Creek in spring, 2004 recorded a diversity index value of 2.080. This was greater than the site average of 1.777. James Canyon Creek, in the spring of 2004, recorded a diversity index value of 1.241. This was below the site average of 1.601. Both Burnout and James Canyon creeks have diversity levels that are reasonably good (see reference levels for Eccles Creek in Shiozawa 2002) although not nearly as high as one would expect for a generally unimpacted system. Part of this may be an artifact associated with the relatively small sample size of three replicates per stream prescribed for these two locations.

Of the two streams, Burnout Creek has tended to have a higher diversity, especially in the fall. This signal is similar to that seen in the CTQa and BCI indices (table 8) for Burnout Creek. Yet the seasonal signal is not apparent in the James Canyon Creek diversity indices. However, in contrast with the CTQa trends, where Burnout Creek appeared to converge towards the conditions existing in James Canyon Creek, the diversity indices indicate that Burnout Creek has maintained a more diverse community than James Canyon. In addition, James Canyon Creek is showing a decline in diversity to levels similar to those in the springs of 2001 and 2002.

Table 9. Diversity indices, based on natural logs, for Burnout and James Canyon Creeks

	Fall 2000	Spring 2001	Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003	Spring 2004
Burnout Creek	2.032	1.459	2.202	1.111	--	1.550	2.310	2.080
James Canyon Creek	1.246	1.519	2.112	1.279	1.747	1.854	1.451	1.241

Cluster Analysis

Cluster analysis (Figure 1) resulted in two main clusters separated at a dissimilarity value of approximately 0.68.

The top cluster (cluster 1) contains all spring samples with the exception of the Burnout Creek, spring, 2004, sampling period. Also in cluster 1 we find three of the seven fall samples, and all three are from James Canyon Creek. Within this cluster we continue to see an emerging dissimilarity with in the James Canyon Creek spring samples. The spring, 2004 sample for James Canyon Creek connects to the fall, 2003 James Canyon sample at a dissimilarity of approximately 0.22. This group separates from the other samples in cluster 1 at a dissimilarity of approximately 0.54.

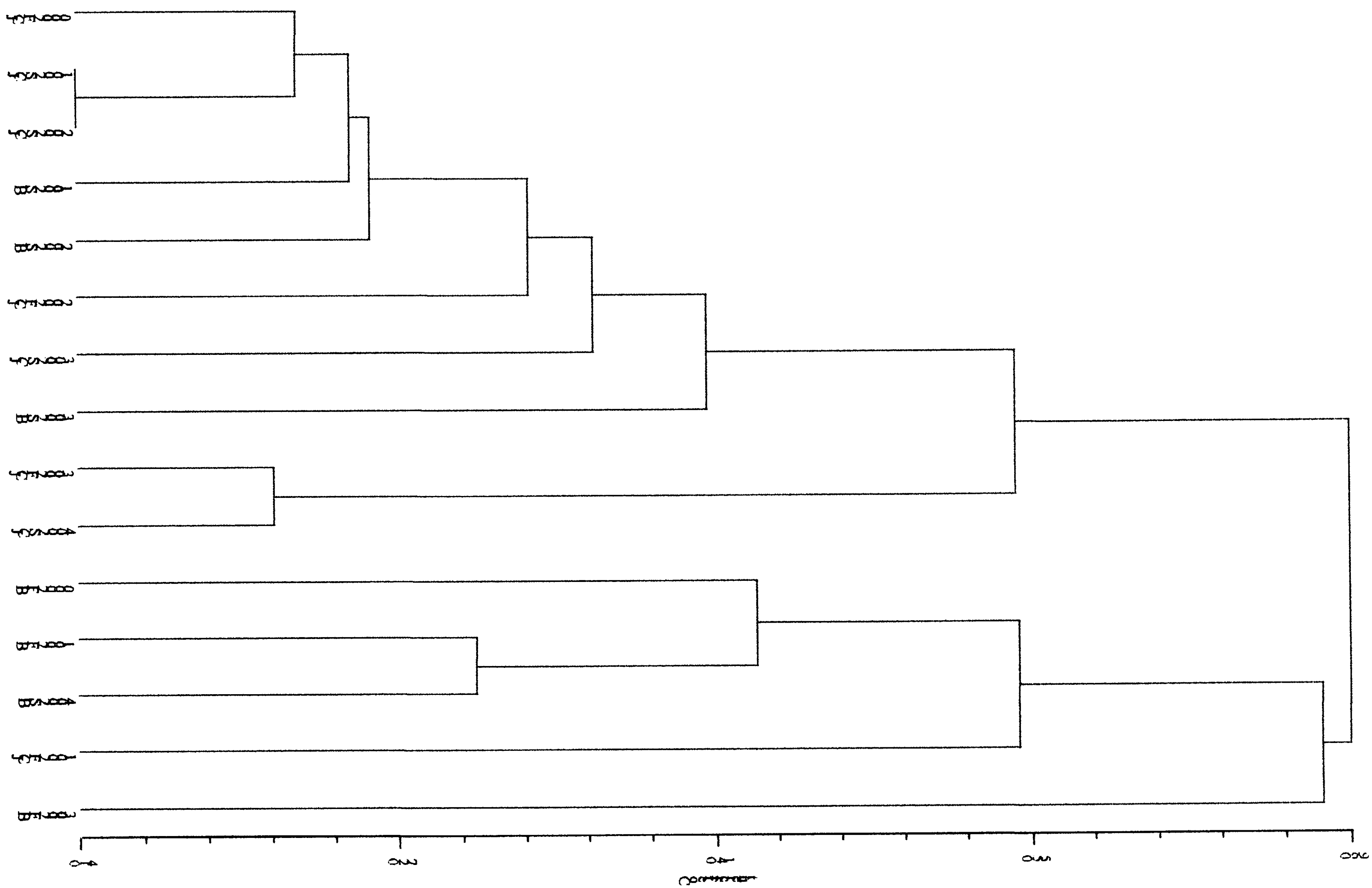

Figure 1. UPGMA Cluster dendrogram of relationships among communities from Burnout and James Canyon Creeks

Within the second cluster (cluster 2), the Burnout Creek fall, 2003 sample is the most dissimilar, separating from the other members of the cluster at a dissimilarity of approximately 0.675, making it divergent enough to be considered a separate entity. Two items are worth noting here. First the only spring sample included in cluster 2 is the spring, 2004 Burnout Creek sample, and the other is that the only James Canyon site included is the fall of 2001.

When the CTQa values are overlain on the cluster, no pattern appears to exist between membership of a site in cluster 1 or 2 and the CTQa score. However the diversity indices clearly associate with the cluster results. All diversity values less than 2.0 (Table 9) are associated with sampling periods when the station was in cluster 1. Conversely, all stations in cluster 2 had diversity index values greater than 2.0. The cluster analysis is clearly detecting the change in taxa, and that change, at least in Burnout Creek is associated with a seasonal cycle where fall samples tend to be more similar to each other.

CONCLUSIONS

Both Burnout Creek and James Canyon Creek for this sampling period had fewer taxa than during the first few years of the study. James Canyon showed an increase in the number of taxa for the spring of 2004. Total invertebrate densities in both streams peaked in the fall of 2003, but by the spring, 2004 sampling period the densities in Burnout Creek were again within the range of its earlier densities. But James Canyon Creek still had higher than average densities. Burnout Creek had an increase in density for six of its 22 taxonomic categories, while in James Canyon Creek chironomids, comprising nearly 71% of the sample, continued to be the dominant taxon. *Baetis* was also abundant relative to past samples, and ostracods were also numerous in this sample.

One factor that may be involved in the increased density of invertebrates is the change in density of fish. In 2001 trout density was down significantly and the low levels that have existed in Electric Lake since the spring of 2002 have discouraged, and likely prevented, spawning access to James Canyon Creek. A significant reduction in juvenile fish could result in changes in the benthic community since reduced fish predation pressure should allow invertebrate prey and invertebrate predators to increase. *Baetis*, for instance, is a primary prey item for stream dwelling trout and ostracods are likely important food for fry and young of the year trout. Elimination of the top vertebrate carnivore could result in a cascade of community changes as various taxa become more abundant or are eliminated by biotic interactions.

Both streams had greater CTQa values in the spring of 2004 than in the fall, 2003 sample period, but showed lower CTQa values than the previous spring samples (spring, 2003), indicating a slight increase in habitat quality. A seasonal signal was apparent in the CTQa values from both streams, tending to be high in the spring and lower in the fall samples. This seasonal signal was also apparent in the diversity indices for Burnout Creek. It had lower diversity in the spring and higher diversity in the fall sample series. This is directly concordant with what the CTQa data predict. However James Canyon Creek did not have any clear seasonal cycle in its diversity and the CTQa values did not correspond with changes in diversity. This suggests that a different set of factors are influencing the dynamics of James Canyon Creek.

Cluster analysis also identifies the seasonal signal in Burnout Creek but is unable to isolate a clear pattern in James Canyon Creek. However one pattern is clearly found with the cluster analysis: high diversity sites clustered together and low diversity sites clustered together. The James Canyon samples which showed no clear trends between diversity and their CTQa values all fell into the low diversity cluster. One pattern that may be emerging within the low diversity cluster is that the two most recent James Canyon Creek samples are diverging from the remainder of samples. The cause of this is unclear, but if James Canyon Creek is undergoing successional changes as the community adjusts to the elimination fo a top predator (ie trout), such a pattern may be the outcome. The high diversity cluster contains the fall samples from Burnout Creek along with the most recent spring Burnout sample.

It appears that the two streams are on different trajectories. These differences may be related to the lack of access of fish into James Canyon. Spawning fish can still be found in Burnout Creek in the spring. The drought should have also had an influence on the stream systems, but both streams would be expected to respond in a similar fashion to drought induced stress. Thus Burnout Creek is the best candidate for interpreting drought induced stresses. Samples taken in 2005 should help in this perspective.

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Appendix A: Sample Data for Burnout Creek Fall 2003

Burnout - Spring 2004		Site 1	Site 2	Site 3	Mean	Density
Ephemeroptera	*Baetis sp.*	137	207	42	128.67	3898.6
	Cinygmula	26	66	33	41.67	1262.5
	Epeorus iron	4	8	0	4.00	121.2
	Early instar Ephemeroptera	32	60	0	30.67	929.2
	Serratella tibialis	9	9	4	7.33	222.2
Plecoptera	Early instar Plecoptera	61	1	0	20.67	626.2
Trichoptera	Trichoptera pupae	0	0	2	0.67	20.2
	Dicosmoecus	0	1	0	0.33	10.1
	Lepidostoma sp.	2	0	1	1.00	30.3
	Neothremma alicia	1	1	2	1.33	40.4
	Rhyacophila sp.	4	3	4	3.67	111.1
Coleoptera	*Heterlimnius* (larvae)	17	13	22	17.33	525.2
	Heterlimnius (adult)	5	4	3	4.00	121.2
	Optioservus (larvae)	0	44	41	28.33	858.5
	Optioservus (adult)	0	2	1	1.00	30.3
Diptera	*Caloparyphus sp.*	1	1	0	0.67	20.2
	Chironomidae *(larva)*	126	154	51	110.33	3343.1
	Chironomidae *(pupa)*	1	1	0	0.67	20.2
	Simulium (larvae)	1	1	30	10.67	323.2
	Tipula (Tipulidae)	0	3	0	1.00	30.3
Crustacea	*Cladocera*	30	1	0	10.33	313.1
	Copepoda	0	0	30	10.00	303
	Ostracoda	271	180	122	191.00	5787.3
Arachnid	*Hydracarina*	31	1	0	10.67	323.2
Mollusca	*Sphaerium sp.*	3	1	0	1.33	40.4
Misc.	*Oligochaeta*	54	173	45	90.67	2747.2
	Planaria	4	32	6	14.00	424.2
	Nematoda	0	1	0	0.33	10.1
	Hemiptera	0	1	0	0.33	
	Collembola	0	2	0	0.67	20.2
	Totals	*820*	*971*	*439*		**22512.9**

*Not used in total taxa counts or calculations for diversity indices.

Appendix B. Sample data for James Canyon Creek Fall 2003

James Canyon - Spring 2004		Site 1	Site 2	Site 3	Mean	Density
Ephemeroptera	*Baetis sp.*	110	110	78	99.333	3009.8
	Cinygmula sp.	16	17	20	17.667	535.3
	Early instar Ephemeroptera	0	9	11	6.667	202
	Serratella tibialis	34	14	61	36.333	1100.9
Plecoptera	Early instar Plecoptera	2	66	8	25.333	767.6
	Isoperla sp.	0	1	1	0.667	20.2
	Paraleuctra sp.	0	0	11	3.667	111.1
	Paraperla	0	1	0	0.333	10.1
Trichoptera	Trichoptera pupa	1	2	1	1.333	40.4
	Dicosmoecus sp.	0	1	0	0.333	10.1
	Lepidostoma sp.	1	0	4	1.667	50.5
	Neothremma alicia	1	89	21	37	1121.1
	Oligophlebodes	96	30	0	42	1272.6
	Rhyacophila	7	77	13	32.333	979.7
Coleoptera	*Optioservus* (larva)	1	0	2	1	30.3
	Optioservus (adult)	0	1	0	0.333	10.1
	Curculionidae	0	0	1	0.333	10.1
Diptera	*Caloparyphus*	1	2	0	1	30.3
	Chironomidae (larva)	2036	2995	885	1972	59751.6
	Chironomidae (pupa)	5	8	1	4.667	141.4
	Ceratopogonidae	0	0	60	20	606
	Dixa sp.	9	1	0	3.333	101
	Hemerodromia sp.	0	1	0	0.333	10.1
	Hemerodromia pupae	2	0	0	0.667	20.2
	Ptychoptera sp.	0	0	1	0.333	10.1
	Simulium sp.	1	1	0	0.667	20.2
	Tipula sp.	1	2	0	1	30.3
Crustacea	*Copepoda*	0	60	30	30	909
	Ostracoda	301	91	305	232.33	7039.7
Arachnid	*Hydracarina*	0	61	31	30.667	929.2
Mollusca	*Sphaerium sp.*	2	0	34	12	363.6
	Gyraulus sp.	0	0	1	0.333	10.1
Misc.	Oligochaeta	60	92	90	80.667	2444.2
	Collembola	0	2	0	0.667	20.2
	Hemiptera	1	0	0	0.333	
	Planaria	10	25	162	65.667	1989.7
	Nematoda	1	0	0	0.333	10.1
	Totals	*2699*	*3759*	*1832*		**83718.9**

*Not used in total taxa counts or calculations for diversity indices.

Appendix C. Tolerance quotients for Burnout and James Canyon Creeks

Burnout and James Canyon Creeks Spring 2004 Taxa	Burnout Creek	James Canyon Creek	Ideal Stream
Ephemeroptera: Baetidae: *Baetis spp.*	72	72	72
Ephemeroptera: Ephemerellidae: *Drunella doddsi*			4
Ephemeroptera: Ephemerellidae: *Drunella grandis*			24
Ephemeroptera: Ephemerellidae: *Ephemerella*			48
Ephemeroptera: Ephemerellidae: *Serratella tibialis*	24	24	24
Ephemeroptera: Heptageniidae: *Cinygmula*	21	21	21
Ephemeroptera: Heptageniidae: *Epeorus iron*	21		21
Ephemeroptera: Heptageniidae: *Heptagenia*			48
Ephemeroptera: Heptageniidae: *Rhithrogena*			21
Ephemeroptera: Leptophlebiidae: *Paraleptophlebia*			24
Plecoptera: Chloroperlidae: *Alloperla*			24
Plecoptera: Chloroperlidae: *Paraperla frontalis*		24	24
Plecoptera: Chloroperlidae: *Sweltza*			24
Plecoptera: Leuctridae: *Paraleuctra*		18	18
Plecoptera: Nemouridae: *Malenka californica*			36
Plecoptera: Nemouridae: *Zapada*			16
Plecoptera: Perlidae: *Hesperoperla pacifica*			18
Plecoptera: Perlodidae: *Diura knowltoni*			24
Plecoptera: Perlodidae: *Isoperla*		48	48
Plecoptera: Perlodidae: *Megarcys signata*			24
Plecoptera: Perlodidae: *Skwalla parallela*			18
Trichoptera: Brachycentridae: *Amiocentrus*			24
Trichoptera: Brachycentridae: *Brachycentrus*			24
Trichoptera: Brachycentridae: *Micrasema*			24
Trichoptera: Hydropsychidae: *Arctopsyche grandis*			18
Trichoptera: Hydropsychidae: *Hydropsyche*			108

Trichoptera: Lepidostomatidae: *Lepidostoma*	18	18	18
Trichoptera: Limnephilidae: *Imania (Allomyia)*			48
Trichoptera: Limnephilidae: *Dicosmoecus*	24	24	24
Trichoptera: Limnephilidae: *Ecclisocosmoecus*			108
Trichoptera: Limnephilidae: *Limnephilus*			108
Trichoptera: Limnephilidae: *Moselyana*			108
Trichoptera: Limnephilidae: *Platycentropus*			108
Trichoptera: Rhyacophilidae: *Rhyacophila*	18	18	18
Trichoptera: Uenoidae: *Neothremma alicia*	8	8	8
Trichoptera: Uenoidae: *Oligophlebodes*		24	24
Coleoptera: Curculionidae		72	72
Coleoptera: Dytiscidae: *Agabus*			72
Coleoptera: Elmidae: *Heterlimnius*	108		108
Coleoptera: Elmidae: *Optioservus*	108	108	108
Coleoptera: Hydrophilidae			72
Coleoptera: Staphylinidae			108
Diptera: pupae			108
Diptera: Athericidae: *Atherix*			24
Diptera: Ceratopogonidae		108	108
Diptera: Ceratopogonidae: Atrichopogon			108
Diptera: Chironomidae	108	108	108
Diptera: Dixidae: *Dixa*		108	108
Diptera: Empididae: *Chelifera*			108
Diptera: Empididae: *Hemerodromia*		108	108
Diptera: Empididae: *Trichoclinocera*			108
Diptera: Empididae: *Wiedemannia*			108
Diptera: Muscidae: *Limnophora*			108
Diptera: Phoridae			108
Diptera: Psychodidae: *Pericoma*			36
Diptera: Ptychopteridae: *Ptychoptera*		108	108

Diptera: Simuliidae: *Simulium*	108	108	108
Diptera: Syrphidae: *Chrysogaster*			108
Diptera: Stratiomyidae: *Caloparyphus*	108	108	108
Diptera: Stratiomyidae: *Euparyphus*			108
Diptera: Tipulidae: *Antocha*			24
Diptera: Tipulidae: *Dicranota*			24
Diptera: Tipulidae: *Tipula*	36	36	36
Crustacea: Cladocera	108		108
Crustacea: Copepoda	108	108	108
Crustacea: Isopoda: *Asellus*			108
Crustacea: Ostracoda	108	108	108
Arachnida: Hydracarina	108	108	108
Mollusca: Planorbidae: *Gyraulus*		108	108
Mollusca: Sphaeriidae: *Sphaerium*	108	108	108
Annelida: Hirudinea			108
Annelida: Oligochaeta	108	108	108
Tricladida: Planariidae	108	108	108
Collembola	108	108	108
Nematoda	108	108	108
Total	1754	2243	5059
Number of taxa	23	30	75
CTQa	76.3	74.8	67.5